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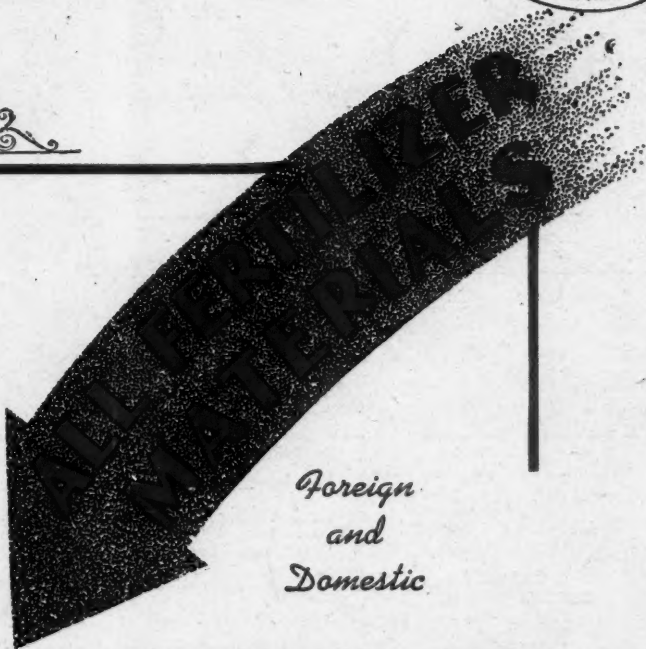


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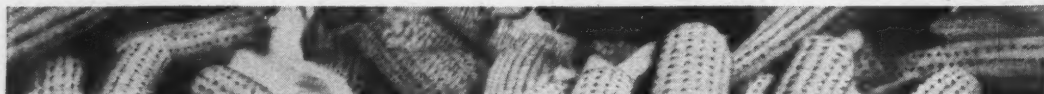
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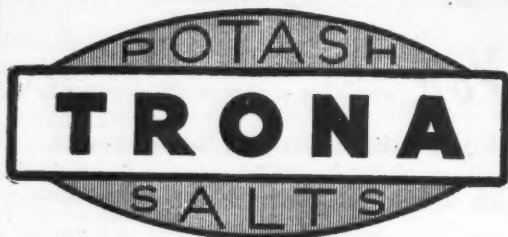
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See page 25





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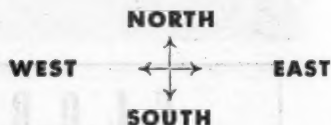
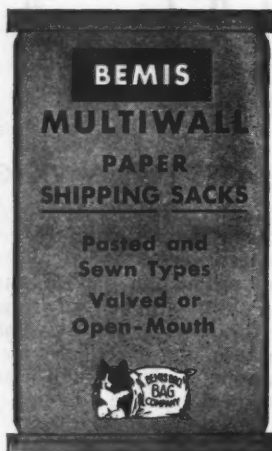
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...THE...

# AMERICAN FERTILIZER

"That man is a benefactor to his race who makes two blades of grass to grow where but one grew before."

Vol. 102

MAY 5, 1945

No. 9

## The Mechanism of Caking\*

By C. K. LAWRENCE

### Introduction

**C**AKING, as used in this paper, is a term applied to the change of state from a mass of discrete, more or less free flowing solid particles to an agglomerated solid mass that is definitely not free-flowing, at least in terms of particles of the initial size. Depending on the nature of the material and its treatment, we may find caking leading to a lightly packed friable condition, or a sluggish damp mass, or under extreme conditions, to a brittle or tough monolith.

Caking is sometimes a desired and profitable behavior, as in the formation of loaf sugar, the setting of cement, etc. In the fertilizer industry, however, it is generally avoided to the extent possible, because farmers require that their solid fertilizers be in the form of free-flowing particles.

In investigations of caking at our laboratory we have encountered some points which may prove of general interest, and which are summarized in this paper.

### Statement of Mechanism

A common and probably general mechanism of caking is crystallization from a liquid phase where solid discrete particles are in intimate contact and at rest. This obviously requires the presence of some liquid containing as a constituent a material which under the conditions it meets is forced to undergo some crystallization in order to attain equilibrium. Although there may be occasional exceptions, the liquid phase responsible for most of the caking in fertilizer materials is due to presence of water, which may have been left in the product as made, or acquired during storage. In the rest of

this paper, we shall discuss some of the mechanics of such systems, the factors commonly leading to caking crystallization and finally some steps that can be taken to minimize caking.

Let us consider first the physical behavior of discrete crystals in contact. Liquid phase is usually present only on the surfaces of the crystals, and is drawn by capillarity into the angles of contact between crystals. The solution is of course saturated with respect to one or more of the solids present, and when, due to factors subsequently discussed, crystallization must occur, it takes place where it can do most harm, that is, where it can cement adjoining crystals together. Complete crystallization and disappearance of liquid phase are not necessary for severe caking. In fact by one or more of the mechanisms discussed later, crystallization can cake a mass of goods with little or no net change in moisture content.

The picture is somewhat different for a product in the form of agglomerated or pebbled particles rather than discrete crystals. Here there are frequently interstices within the particles which tend to draw liquid inside the grains, where crystallization does no harm. As a rule, products of this type cake less severely than the same material in the form of non-porous crystals. The situation is similar for a product coated with a finely divided nonhygroscopic material.

We have prepared some pictures to illustrate this mechanism. In Figure 1 is shown a layer of ammonium nitrate-coated particles in contact, after humidification that resulted in absorption of considerable moisture. Notice how a large portion of the liquid accumulates at points of particle contacts. Figure 2 shows this same set-up after exposure to low humidity, which evaporated

\*A paper presented at the meeting of the American Chemical Society, held at New York, September, 1944.

the water. This has formed, as you will see, rigid bridges between particles, and the layer has become in effect a single solid piece.

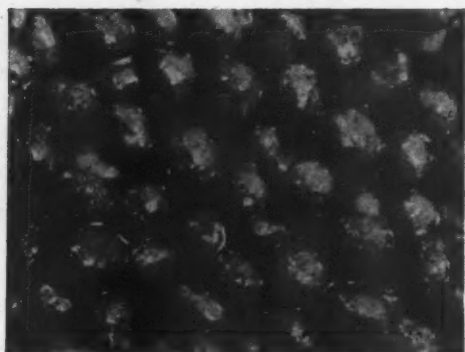


Fig. 1—A layer of ammonium nitrate-coated particles after humidification

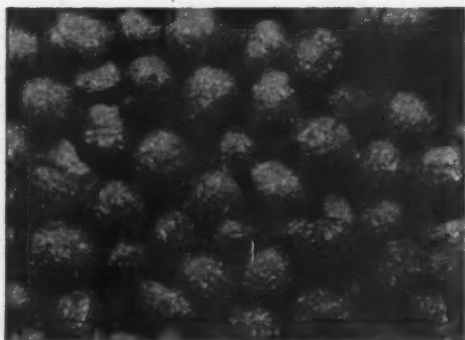


Fig. 2—A layer of ammonium nitrate-coated particles after evaporation of absorbed moisture

#### Factors Influencing Caking

**Hygroscopicity:** When we come to discuss the factors inducing crystallization, the relations between humidity and physical behavior of soluble materials are so fundamental as to justify a brief review. Adams and his coworkers published an informing pair of articles on this general subject in *Industrial and Engineering Chemistry*<sup>1</sup> some years ago, which can be consulted with profit by those who desire information of a more quantitative nature than will be given in the present paper.

A saturated solution of a pure salt is characterized, at a given temperature, by a

constant vapor pressure. This means that at relative humidities below that corresponding to this critical vapor pressure, the salt is in equilibrium with the atmosphere only when dry; and at higher relative humidities than this critical value, only when completely dissolved.

For our discussion of hygroscopicity, it will be convenient to illustrate the general relations between atmospheric moisture, expressed as relative humidity, and the moisture content of salts exposed thereto until equilibrium is reached. After reviewing in general terms these relations for pure and impure salts of nonhydrating and of hydrating types, we shall have occasion to consider quantitatively a set of relations determined for a few specific materials.

Figure 3 illustrates these relations graphically in terms of equilibrium moisture content of a pure nonhydrating salt as a function of the relative humidity to which it is exposed. At that value of the relative hu-

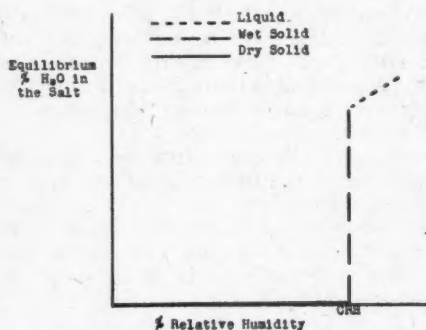


Fig. 3—Moisture equilibria for a pure non-hydrating salt

midity labeled CRH, the moisture vapor in the air is at a partial pressure equal to the vapor pressure of a saturated solution of the salt. If we start out with a dry salt exposed to a low humidity, i.e., below that of the critical relative humidity for that salt, the salt will not pick up any moisture from the atmosphere. If we increase the humidity to any value up to but not including the critical relative humidity, the salt still remains dry. In other words the equilibrium moisture content of a pure salt at all values of humidity up to but not including the critical relative humidity is zero. If now we increase the humidity to some value above that which is critical for the salt, the moisture vapor pressure in the atmosphere is greater than that of a saturated solution of the salt and hence

<sup>1</sup>*Ind. Eng. Chem.*, 21, pp. 305-7, (1929); 25, pp. 136-8, (1933).



the salt absorbs moisture. If the high humidity is sustained, the salt will continue to absorb moisture until it is completely dissolved, and by further absorption of moisture the solution is diluted to such a point that its vapor pressure is equal to the partial pressure of the water vapor in the atmosphere to which it is exposed. Thus a wet pure salt is in equilibrium with the atmosphere above it only when the relative humidity of the atmosphere corresponds to the critical relative humidity of the salt. In the changes discussed just above we have assumed a situation where the atmospheric conditions are controlled by outside influences, and determine the physical state of the salt. However under conditions where a wet salt is confined so that the atmosphere about it changes but little or not at all, the wet

as corresponding to that in equilibrium with the saturated solution.

Combinations of salts are generally more hygroscopic than the individual components. This is significant not only for typical fertilizer mixtures, but also for the effects of impurities in technical grades of commercial salts.

The behavior of mixtures of two salts is shown on Figure 5. Salts A and B separately have equilibrium moisture relations as shown by the lines marked A and B respectively, as previously discussed for pure nonhydrating salts. B as shown on Figure 5 is more hygroscopic than A. Mixtures of A and B will behave differently depending upon the proportions in which the salts are mixed. When we mix A and B in the same proportions as they exist in a water solution saturated with

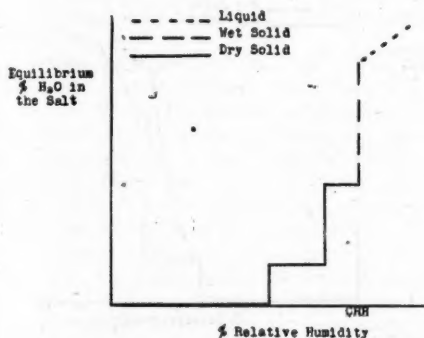


Fig. 4—Moisture equilibria for a pure hydrating salt

salt will condition the air to a fixed humidity corresponding to the critical relative humidity for the salt.

The critical relative humidity is different for different salts. It varies roughly inversely with solubility. The more soluble a salt is, the lower is the vapor pressure of its saturated solution; consequently, the lower its critical relative humidity and the greater its hygroscopicity.

The situation is somewhat more complicated for a pure salt capable of taking on water of hydration, as shown on Figure 4. Here there are definite values of relative humidity corresponding to equilibria between levels of hydration of the salt. However at equilibrium the hydrating salt does not become wet at values of humidity below that corresponding to vapor pressure of the saturated solution of the salt and again we may use the term critical relative humidity

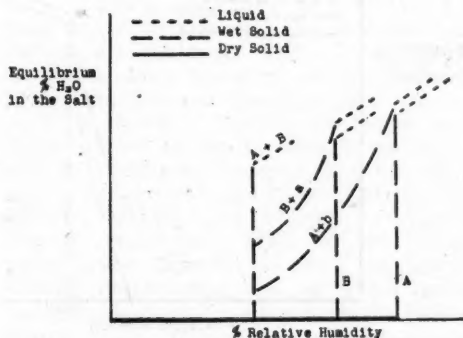


Fig. 5—Moisture equilibria for two pure non-hydrating salts and their mixtures

both A and B, the moisture relations are similar, as shown by the line marked A+B on Figure 5, to those of a pure salt. Exposure of a dry mixture to a humidity above the critical value results in complete dissolution of the two salts simultaneously, followed by dilution of the solution until the vapor pressure reaches that of the water vapor in the atmosphere. The critical relative humidity of the combination is typically below that for either B or A. If we mix a small proportion of B with A and then expose it to increasing humidities, the combination will begin to absorb moisture at the critical relative humidity for A+B until B is completely dissolved. This, of course, will occur at a lower moisture content than the water content of a solution saturated with both A and B. Further moisture absorption follows the line marked A+b, with solid phase A wet by a solution saturated with A

and becoming more and more diluted with respect to B as moisture content increases. At higher moisture contents it approaches the critical relative humidity of A before A is completely dissolved. The analogous situation for salt B containing a small proportion of salt A is shown by line B+a. Since only small quantities of water are needed for caking by various mechanisms discussed later, the moisture relations for salt mixtures are more pertinent to the problem of caking than are the relations for the pure salt, except in cases where we are dealing commercially with unusually pure materials.

The relations for commercial salts containing one or more impurities in small amounts are shown typically in Figure 6. The vertical line at humidity value marked

ture is the relative humidity in equilibrium with the salt at 0.05 per cent moisture content, and is the value we have used for critical relative humidity of that particular product. We shall have occasion to refer quantitatively to an illustrative set of data along these lines later in the paper.

Impurities have corresponding effects on hydrating salts, as shown in Figure 7. Line 1, with moisture content increasing in rectangular steps at definite humidity values, is a repetition of a previous figure for a pure hydrating salt. Line 2 shows the behavior of this salt with a small amount of a nonhydrating soluble impurity. The product becomes wet before it is fully hydrated, and passes through its normal levels of hydration. Line 3 shows the influence of an impurity with sufficient effect to reduce the vapor pressure

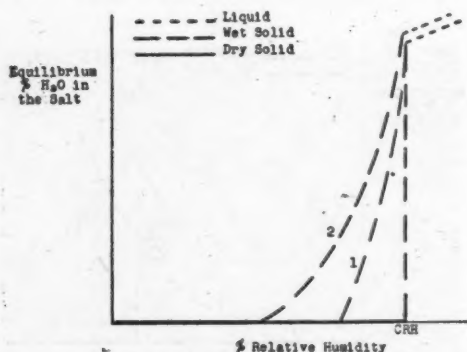


Fig. 6—Moisture equilibria for a nonhydrating salt with impurities

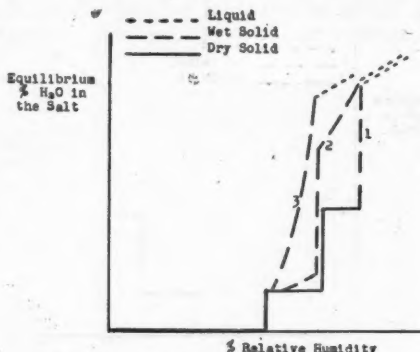


Fig. 7—Moisture equilibria for an impure hydrating salt

CRH depicts the behavior of the pure salt as previously discussed. The lines marked 1 and 2 represent the behaviors of products with a relatively small amount and a relatively large amount of soluble impurities, respectively. In the case of products with small concentrations of impurities it is frequently difficult to detect a sharply defined critical relative humidity above which the product becomes wet. We have found it convenient to select arbitrarily for nonhydrating salts an equilibrium moisture content of 0.05 per cent and state that the humidity in equilibrium with the product at that moisture content is the critical relative humidity for that product. Viewed another way, a given product at a given temperature and with this arbitrarily chosen moisture content of 0.05 per cent has a fixed vapor pressure. The ratio (multiplied by 100) of this vapor pressure to that of pure water at the same tempera-

ture is the relative humidity in equilibrium with the salt at 0.05 per cent moisture content, and is the value we have used for critical relative humidity of that particular product. We shall have occasion to refer quantitatively to an illustrative set of data along these lines later in the paper.

The soluble products and their combinations commonly used in fertilizer mixtures have critical relative humidities within the range of atmospheric humidities encountered in storage and shipment of the materials. From our discussion of hygroscopicity, it will then be evident that even if a product is put into storage dry, it commonly tends to acquire some moisture during storage unless costly measures are taken to prevent it. Once the liquid phase is present, either by absorption from the atmosphere or by its having been in the goods when stored, it can serve as the medium for the crystallization which means caking. Several factors can induce this crystallization.

(Continued on page 24)

## Phosphate Rock Industry of the Western States In 1944

**A** NEW high record for phosphate rock production in the Western States was set in 1944, the marketed production reaching 298,999 long tons, (with a  $P_2O_5$  content of 95,767 tons). This was an increase of 13 per cent above the previous high of 1942, and 70,319 tons (31 per cent) more than the quantity sold or used in 1943, according to reports by producers to the Bureau of Mines, United States Department of the Interior. The total value was slightly more than  $1\frac{1}{8}$  million dollars. The production in 1944 came from Idaho and Montana; Utah was inactive. The average  $P_2O_5$  content of the Western States phosphate rock sold or used in 1944 is reported as 32.02 per cent.

Idaho rock sold or used in 1944 (112,565 long tons with 35,804 tons  $P_2O_5$  content) was still below the record production of 1942 (114,079 tons), although only 1 per cent compared with 5 per cent in 1943. The average  $P_2O_5$  content was 31.80 per cent. The same two companies were active in this State in 1944 as in 1943 and 1942. By far the larger of these, the Anaconda Copper Mining Co., operated its No. 3 mine at Conda, Caribou County. Most of the Conda shipments in 1944 went to Anaconda, Montana, for conversion to superphosphate. Much smaller quantities were used for the manufacture of phosphate chemicals, for direct application to the soil, for stock and poultry

feed, and for fertilizer filler. Some was exported for acidulating. The other producer, the Teton Phosphate Co., Boise, Idaho, mined phosphate rock from its Bennington mine in Bear Lake County, near Montpelier. This material was ground in the company plant and sold for direct application to the soil.

Montana was the largest phosphate rock producer of the Western States group in 1944 as in recent years, its lead in phosphate rock sold or used over Idaho increasing to 73,869 long tons. Its total in 1944 (186,434 tons with a  $P_2O_5$  content of 59,963 tons) exceeded the record of 1942 (150,402 tons) by 24 per cent. The average  $P_2O_5$  content was 32.16 per cent. Three mining companies were operating in the State in 1944. The Montana Phosphate Products Co., of Trail, British Columbia, the largest producer in 1944 in the Western States, operated its Anderson, Graveley, and Anaconda mines, and also its leases (Great Falls 076740, 081920, 077348, and 076890) in Powell County, Montana. Most of the mined product was exported to the Consolidated Mining and Smelting Co., at Trail, but a considerable quantity was sold in the United States. The International Minerals and Chemical Corporation, which in 1942 acquired the Federal lease of the Northwestern Improvement Co., St. Paul, Minn., in the Douglas Creek area, Granite County, Mon-

WESTERN STATES PHOSPHATE ROCK SOLD OR USED BY PRODUCERS, 1940-44

Year	Idaho			Montana		
	Long tons	Value at mines Total	Average	Long tons	Value at mines Total	Average
1940	99,088	\$441,598	\$4.46	64,239	\$184,844	\$2.88
1941	97,274	444,154	4.57	105,108	318,588	3.03
1942	114,079	511,249	4.48	150,402	572,464	3.81
1943	108,916	561,630	5.16	119,764	488,665	4.08
1944	112,565	584,400	5.19	186,434	761,745	4.09

Year	Utah			Total		
	Long tons	Value at mines Total	Average	Long tons	Value at mines Total	Average
1940	...	...	...	163,327	\$626,442	\$3.84
1941	1,340	\$8,535	\$6.37	203,722	771,277	3.79
1942	1,184	7,410	6.26	265,665	1,091,123	4.11
1943	...	...	...	228,680	1,050,295	4.59
1944	...	...	...	298,999	1,346,145	4.50

tana, carried on considerable development work at the mine in 1944. It mined a few thousand tons of phosphate rock and treated it in a large test mill recently erected at Sherryl, on the Philipsburg branch of the Northern Pacific about 7 miles from the mine, producing a considerable tonnage of higher grade concentrates. No sales or shipments of the material were made, however, in 1944. Lee H. Skeels, trustee for the Soluble Phosphates, Ltd., Maxville, Granite County, Montana, mined a small tonnage at the mine near Maxville in 1944, but made no shipments during the year.

No phosphate rock was produced in Utah in 1944. The Garfield Chemical and Manufacturing Corporation, Salt Lake City, Utah, which mined and shipped phosphate rock in 1942 from a Federal lease near Spanish Fork, Utah County, for use in pig-iron blast furnaces, made no production either in 1943 or 1944.

The average value per ton of the Western States phosphate rock sold or used, as reported by producers to the Bureau of Mines, dropped 9 cents from \$4.59 in 1943 to \$4.50 in 1944. There was an increase of three cents per ton in Idaho, and one cent per ton in Montana.

### Basingpoint Prices Upset

The United States Supreme Court has ruled against basingpoint methods used in pricing glucose, in its interpretation of the Robinson-Patman amendment to the Clayton act. The court insists that the Clayton act as amended "places emphasis on individual competitive situations, rather than upon a general system of competition."

The decision affects the common practice in using price basingpoints. OPA followed business usage in determining maximum prices. In view of the court decision OPA has issued the following statement:

The two decisions hold that adherence to a basingpoint system of pricing under circumstances such as were found by the Federal Trade Commission to have existed in those cases constitutes unlawful discrimination violative of section 2 (a) of the Clayton act, as amended by the Robinson-Patman act. It seems clear from the decisions, however, that basingpoint pricing is not violative of the law under all circumstances.

Whether, and to what extent, if any, it may be necessary for maximum price regulations to be amended in view of the corn products and

Staley cases can be determined only after careful study of the two Supreme Court opinions.

While this study is being completed, compliance with the regulations will not compel any seller to violate the Robinson-Patman act. The price-discrimination that might under some circumstances flow from charging the full maximum price permitted by a regulation can always be avoided by charging a lower price that will not cause discrimination in favor of the seller's other customers.

A seller who has been found by the trade commission or a court to be in violation of the Robinson-Patman act and who would sustain substantial hardship if he eliminated price-discrimination by lowering his higher prices to conform to that act may apply under supplementary order No. 41, issued by OPA two years ago, for permission to increase lower maximum prices to those purchasers in whose favor he has been found to have discriminated.

### CCC to Pool Crop-Loan Cotton

The War Food Administration has announced that all 1943-crop cotton under loan on August 1, 1945, will be pooled for producers' account by the Commodity Credit Corporation. Meanwhile the cotton producers having loans on the 1943 crop may repay loans and redeem their cotton under the terms of the 1943 cotton crop loan provisions.

On final liquidation of all 1943 cotton in the pool by CCC, the net proceeds, if any, after deduction of all advances and accrued costs including storage, insurance, and handling charges, will be distributed among producers whose cotton has been placed in the pool, in proportion to their interest.

No payment is to be made to the producers at the time the cotton is placed in the pool. The average 1943 loan rate for 15/16 inch middling cotton, net weight, was 20.06 cents per pound.

### Tankcar Demurrage When Strikes Occur

The Interstate Commerce Commission has issued a modification of its tankcar demurrage order to deal with situations created by strikes. Under the new order, when a strike prevents a car from being moved within the free-time period, demurrage charges against the receiver are to be held in abeyance until conditions permit the movement of the car.



# IT MAY BE

By SAMUEL L. VEITCH

## Post-war Subsidies

The Byrnes report would appear to make increased direct subsidies a reconversion period policy of the Administration. And, we again quote Byrnes: "Situations may arise (in the case of some of these commodities) in which it would ultimately cost the government less, and be to the long-time interest of producers, to permit the prices to decline below the authorized support price level, and make up the difference with direct government payments.

"Because of the competition from foreign producers, and from other commodities in this country, this procedure may prove to be the most practical way to meet the problem in such cases."

He suggested that Congress authorize administrative agencies to make payments in lieu of support prices, "whenever as a result of a decline in domestic consumption and exports it is determined that the support prices are resulting in the accumulation of surpluses, and when the over-all cost of the government would be reduced by substitution of direct payments for price support." The object of the Byrnes plan is to make a plentiful supply of food available at prices which will encourage full consumption.

## : The Cotton South

Down South they are talking seriously about the future of cotton. Cotton fiber is piling up into a large surplus, enough, in fact, to meet world demands for a year. Then there is the ever-increasing popularity of synthetic fiber—rayon made from wood fiber and nylon made from coal.

But is the South going to give up growing cotton? Absolutely not. Cotton is too valuable a crop to give up. It produces fiber for clothing, bagging and household necessities; oil for cooking and oleomargarine as a butter substitute; meal of high protein content for livestock feed, and flour for bread; linters—the fuzz of the cotton seed—for felt, insulation and even for making rayon, and cottonseed hulls for feed and base for linoleum—just to mention some of

the more important uses of the products of the cotton plant.

Agronomists and farmers believe that cotton will hold its own in the South through soil improvement, planting high yielding varieties, liberal fertilization, and the use of labor-saving machinery to reduce the rather high labor cost of cotton growing.

The surplus of cotton fiber, now on hand, it is thought, will be absorbed by the war-ragged world which will also take all the cottonseed oil and meal that can be made.

A longer-range view recognizes that other cotton-growing countries are exceeding the output of the United States, and are producing it with low-cost labor, and is leading to the conclusion that a winning policy to be followed in this country is to grow more cotton on fewer acres.

On acres released from cotton, southerners are giving serious thought to sweet potatoes, a crop that provides human food, feed for livestock, and material for industrial alcohol and starch.

Peanuts are also in high favor. This crop also produces food and feed, and is a valuable source of edible oil.

Along with the changes taking place in southern agriculture is the increase in livestock production. The South is beginning to realize that all conditions for success with livestock can be easily met. The greatest weakness has been lack of good pastures. This is being overcome by the use of fertilizers and lime. Eight to nine months' grazing period each year is quite an advantage for the South, an advantage fully capitalized upon only when improved, high yielding pastures are developed.

Less than half the horses and mules are on farms now as there were during the first World War. The reduction is from 26 and  $\frac{3}{4}$  million to 12 and  $\frac{1}{2}$  million of which about 9 million are horses and 3 and  $\frac{1}{2}$  million mules. The drop in the number of horses has been faster than for mules, and in 5 years, it is estimated there will be only about 10 million horses and mules. The reason, farm mechanization.

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## Efficiency Trend in Agriculture

Increased production with decreased manpower during the war, indicates that agriculture is attaining greater efficiency. But the trend toward greater efficiency on the farm has only been accentuated by the war, for it is well known that the farm population has been decreasing for a generation, yet agricultural production has increased continuously.

Greater production with less manpower is generally ascribed to the introduction of labor-saving machinery on the farm. While farm machinery has been important to obtaining greater production per unit of manpower, it is only one of the factors operating for greater efficiency on the farm. In fact, so few labor-saving machines have been available during the war that it is doubtful that farm machinery has been a major factor in recent achievements on the farm. If more machinery had been available doubtless farm production would have been greater, and there is every indication that farm machinery will become a greater contributor to farm efficiency as soon as it is again made available to meet demands.

Credit for increased farm efficiency must include soil conservation, the use of improved high-producing seed, application of more commercial plant food of the kind and quantity found to be best, the use of better methods of disease and insect control, advances in the use of more purebred, high-producing livestock—in fact, the application of knowledge attained through research and the farmers' past experiences.

The trend is clearly toward larger than toward smaller farms, primarily because greatest efficiency in the use of labor-saving machinery calls for greater acreage. But, while labor-saving machinery means more acres per farm, the real goal of farm efficiency is more yield per acre through soil conservation, high-yielding seed, ample fertilization, crop protection and thorough cultivation.

Success on farms in the future, in fact, lies in increased operating efficiency whereby the costs per unit of production will be lowered to widen the margin of profit. To this end, more per acre provides the farmer's greatest opportunity.

Agricultural achievements during the war have taught valuable lessons in farm efficiency and have left lasting impressions of possibilities that will not be forgotten.

### **Techter Succeeds Haskell in Barrett Organization**

S. B. Haskell has resigned as manager of the Sales Agency Department, The Barrett Division, Allied Chemical & Dye Corporation. He is being succeeded by Fred T. Techter, who from May 1st on is in charge of sales of nitrogen products for Barrett. Mr. Haskell will, however, continue with Barrett in an advisory capacity.

### **TVA Mobile Phosphate Plant Proposal Killed**

Conferees on the independent offices appropriation bill eliminated a \$3,000,000 appropriation for the construction of a superphosphate plant by Tennessee Valley Authority at Mobile, Ala.

No protest against eliminating this amendment to the bill was made on the floor of either house when the measure came up for final action.

The new Hill-Bankhead bill calls for a larger appropriation for the plant which probably accounts for the absence of protests from these and other sponsors of the newer bill.

### **Louisiana Ammonium Nitrate Plant Enlarged**

Reconstruction Finance Corporation has announced that the Defense Plant Corporation has authorized an increase in its contract for additional facilities to be installed at a Lake Charles, La., ammonium nitrate plant, involving an expenditure of \$80,000. Mathieson Alkali Works, Inc., New York, operators of the plant, produce ammonia and ammonium nitrate.

### **Relation of Fertilizers to Cotton Boll-Weevil Poisoning**

Relations of the rate of fertilizer applications to cotton with and without poisoning for boll-weevil control, have been studied by the Alabama Experiment Station for a period of 18 years. Applications of fertilizer per acre were 500, 1,000, 1,500 and 2,000 pounds.

On unfertilized plots poisoning for boll-weevil control accounted for an average increase of 46 pounds of seed cotton per acre. The average increase in yields for the different

fertilizer applications on poisoned areas was 215, 263, 394 and 380 pounds of seed cotton per acre for the first, second, third and fourth 500-pound increases in the rate of fertilization.

In other words, the value of poisoning for boll-weevil control increased with the rate of the fertilizer applied.

## **Obituary**

### **J. DeWitt Toll, Jr.**

John DeWitt Toll, Jr., of the Peninsular Fertilizer Works, Tampa, Fla., died on April 23rd at Lakeland, Fla. Death was due to heart failure during a tonsil operation.

Mr. Toll, who had reached his 50th birthday on April 20th, was the son of the late John D. Toll, formerly secretary of the National Fertilizer Association and editor of THE AMERICAN FERTILIZER. He received his education in the Philadelphia schools and at Lafayette College. During World War I he served with the American Ambulance, attached to the French Army, from June, 1917, until the end of the war, and later spent several months at one of the Rhine bridge-heads.

After the war he joined the staff of the American Agricultural Chemical Co., and in 1925 entered the employ of the Alsatian Potash Company. When this organization became a part of the N. V. Potash Export My., Mr. Toll was made manager of their Atlanta office. When the company was discontinued at the start of World War II, he went with the French Potash & Import Co. For the past two years he has been with the Peninsular Fertilizer Works.

Mr. Toll is survived by his widow, a son and a stepson serving with the armed forces.

### **A. L. Tichane**

A. L. Tichane, advertising manager of the Fertilizer Division of American Cyanamid Company, died on April 19th, following an illness of several months' duration.

### **William G. Carroll**

William G. Carroll, president of United Chemical Company, Dallas, Texas, died on April 25th. Mr. Carroll, who had a wide acquaintance among the fertilizer industry, was for many years a partner in the company. Since its incorporation, he has served as president.

## New High Record in Land Terracing

A new high record was set in the amount of land terracing in South Carolina in 1944. A total of 146,890 acres were terraced on 3,777 farms, according to C. V. Phagan, extension agricultural engineer. Two-thirds of the total acreage were terraced with farm equipment, he stated.

## April Tax Tag Sales

Fertilizer tax tag sales in April were substantially larger than in the corresponding month of the last three years. The aggregate increase over April, 1944, in the 17 states combined, was more than 175,000 tons. In-

creases were reported by 14 states and declines by three. Sales in the South were 19 per cent above April, 1944, compared with a 56 per cent rise in the Midwest.

Total sales in the first four months of 1945 exceeded sales in January-April, 1944, by 7 per cent, the net result of increases of 6 per cent in the South and 18 per cent in the Midwest.

Sales in the first 10 months of the current fiscal year, July through April, were 365,000 tons larger than for the same period last year and 1,145,000 tons larger than for two years ago. Comparative figures are shown below.

	1944-45	1943-44	1942-43
South.....	6,213,000	6,016,000	5,426,000
Midwest.....	1,035,000	867,000	677,000
Total.....	7,248,000	6,883,000	6,103,000

## FERTILIZER TAX TAG SALES

STATE	APRIL		1943 Tons	% of 1944	JANUARY-APRIL		1943 Tons
	1945 Tons	1944 Tons			1945 Tons	1944 Tons	
Virginia.....	63,023	62,471	58,489	111	311,088	279,333	273,724
North Carolina.....	219,771	180,532	201,706	111	1,041,909	939,072	978,995
South Carolina.....	95,890	89,003	98,148	104	601,868	576,031	645,895
Georgia.....	138,576	102,224	106,538	106	817,685	772,123	804,714
Florida*.....	55,830	52,104	54,040	104	330,412	318,826	275,175
Alabama.....	93,150	62,000	87,800	106	564,150	531,250	568,800
Mississippi.....	41,250	32,710	50,800	95	259,417	272,304	291,736
Tennessee.....	54,400	51,133	54,273	106	173,650	163,443	154,039
Arkansas.....	9,950	15,050	24,935	92	79,900	86,983	135,485
Louisiana.....	24,100	13,685	29,150	90	112,186	124,085	137,063
Texas.....	22,910	30,940	24,050	99	123,035	123,576	113,230
Oklahoma.....	3,000	180	2,400	139	14,662	10,551	14,571
Total South.....	821,850	692,032	792,329	106	4,429,962	4,197,577	4,393,427
Indiana.....	26,836	26,507	40,325	96	144,448	149,737	197,125
Illinois.....	37,500	10,580	7,012	153	113,425	74,130	53,734
Kentucky.....	54,013	38,025	27,625	121	171,458	141,574	92,003
Missouri.....	10,880	5,676	5,272	126	83,017	65,865	42,346
Kansas.....	950	2,620	1,291	96	13,865	14,476	3,290
Total Midwest.....	130,179	83,408	81,525	118	526,213	445,782	388,498
Grand Total.....	952,029	775,440	873,854	107	4,956,175	4,643,359	4,781,925

\*Revised by eliminating the tonnage of raw phosphate rock and liming materials for earlier periods.

# BRADLEY & BAKER

## FERTILIZER MATERIALS - FEEDSTUFFS

### AGENTS - IMPORTERS - BROKERS

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Norfolk, Va.

Barnett Bank Building  
Jacksonville, Fla.

504 Merchants-Exchange Bldg., St. Louis, Mo.



## FERTILIZER MATERIALS MARKET

### NEW YORK

**Withdrawal of Nitrogen Solutions from Fertilizer Market Adds to Nitrogen Shortage. Sulphate of Ammonia in Great Demand. No Improvement in Superphosphate Production. Potash Supplies Adequate with New Prices Expected Shortly.**

*Exclusive Correspondence to "The American Fertilizer"*

NEW YORK, May 3, 1945.

#### **Sulphate of Ammonia**

There has been no easing up in the sulphate of ammonia situation. Mixers are taking all materials as fast as they can be produced and shipped. The withdrawal of nitrogen solutions from the fertilizer market has placed upon sulphate the burden of supplying the major portion of nitrogen in mixed fertilizers.

#### **Nitrate of Soda**

While April shipments of nitrate of soda were the smallest for several months, the War Shipping Administration has assigned additional ships which are expected to arrive during May. Consequently, May allocations are expected to be the largest of any month this year. This will not solve the mixer's problems, however, as the use of nitrate of soda is restricted to direct application only. April prices for domestic nitrate have been continued throughout May.

#### **Organic Ammoniates**

The reduced meat supply is reflected in the increased tightness in the organics market. Practically no material is being offered for immediate shipment and the feed trade is taking what few small lots appear on the market. A few sales of hoof meal for fertilizer use have been reported.

#### **Superphosphate**

The same old story continues in the superphosphate market. Acidulators are shipping on contracts as much material as the manpower shortage will permit them to produce. No supplies are available for additional requirements and the end of the season will not see any stocks held over.

#### **Phosphate Rock**

The demand from superphosphate producers has continued good and producers have been able to fill all requirements, in spite of some transportation difficulties. OPA has

permitted an increase of 25 cents per ton on Tennessee brown rock where a fineness of 85 per cent through a 300 mesh screen is guaranteed.

#### **Potash**

Producers have been able to meet all requirements but no reserve stocks are accumulating. Transportation continues to be a major problem. Prices for the coming year, which normally would be announced about May 1st, have been delayed for a few weeks.

### CHARLESTON

**Better Progress in Shipments Being Made. All Nitrogen Materials in Short Supply. New Potash Prices Awaited.**

*Exclusive Correspondence to "The American Fertilizer"*

CHARLESTON, May 1, 1945.

The fertilizer manufacturers are just now beginning to catch up on their shipping orders, though some are still behind.

**Organics.**—The situation continues the same on these, no blood, castor pomace, or bone meal being offered.

**Nitrate of Soda.**—Allocations of this material for the month of May are the largest so far for the present season. This is based on cargo arrivals, however, and deliveries may not be able to be secured until June.

**Ammonium Nitrate.**—This continues short as munition demands are taking up the American production, and Canada has not been able to fill March allocations.

**Sulphate of Ammonia.**—Supply continues short.

**Potash.**—New contract prices for the 1945-1946 season are expected in the next few days at probably the same basis as the past season.

In the post-war period it is going to be just as important to know what to produce as to know how to produce it.—*Secretary of Agriculture Claude Wickard.*

# Fertilizer Materials



Let us Quote on **YOUR** Requirements

PHOSPHATE ROCK  
SUPERPHOSPHATE

DOUBLE SUPERPHOSPHATE

SULPHURIC ACID

BONE MEALS

DRIED BLOOD

TANKAGES

BONE BLACK

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Columbus, Ga.  
East St. Louis, Ill.  
Greensboro, N. C.  
Havana, Cuba  
Houston, Texas  
Jacksonville, Fla.

Nashville, Tenn.  
New Orleans, La.  
New York, N. Y.  
Norfolk, Va.  
Presque Isle, Me.  
San Juan, P. R.  
Sandusky, Ohio

Montgomery Ala

Wilmington, N. C.

## CHICAGO

**No Change in Fertilizer Organics Situation, but Demand Has Slackened. Feed Materials Still at Ceiling Prices.**

*Exclusive Correspondence to "The American Fertilizer"*

CHICAGO, April 30, 1945.

The organic situation is unchanged. Supply has not materialized but, naturally, due to the lateness of the season, demand is not as urgent as it was earlier.

There is no abatement in the heavy demand for digester tankage and meat scrap, while production continues light. Ceiling prices, therefore, are easily maintained.

Ceiling prices are:

High grade ground fertilizer tankage, \$3.85 to \$4.00 (\$4.68 to \$4.86 per unit N) and 10 cents; standard grades crushed feeding tankage, \$5.53 per unit ammonia (\$6.72 per unit N); blood, \$5.53 (\$6.72 per unit N); dry rendered tankage, \$1.25 per unit of protein, f. o. b. producing points.

## Higher Analysis Fertilizers Bill in South Carolina

Senate Bill 247 of the South Carolina Legislature establishes a minimum plant food content of fertilizers at 20 per cent, except where the nitrogen in fertilizer is 25 per cent or more of an insoluble nature, in which case the minimum plant food content may be 18 per cent. Superphosphate may have a minimum plant food content of 18 per cent.

The bill also provides for permissible ratios for grades of complete fertilizers in which a war policy to this effect is made permanent.

## Southern Railroads Rate Probe

Eighteen southern railroads petitioned the Supreme Court of the United States for a reconsideration of its decision in the case insti-

tuted by Governor Ellis Arnold of Georgia, alleging discriminatory freights in the South. The petition was denied. The complaint which alleged conspiracy to maintain special rates in the South was accepted by the Court 5 to 4 on March 26th. The action is considered preliminary to steps looking to revision of railroad rates.

## March Sulphate of Ammonia

The figures of the U. S. Bureau of Mines show that production of by-product sulphate of ammonia during March totaled 70,412 tons, an increase of 12.7 per cent over February, which is accounted for by the longer month. For some time the country's output has kept fairly steady at about 2,300 tons per day. Sales also rose to 82,932 tons and the figure for stocks on hand accordingly dropped to 34,452 tons by the end of March. Production for the first quarter of the year amounted to 200,247 tons, compared with 202,143 tons for the first quarter of 1944.

	Sulphate of Ammonia Tons	Ammonia Liquor Tons NH <sub>3</sub>
<b>Production</b>		
March, 1945.....	70,412	2,412
February, 1945.....	62,504	2,260
March, 1944.....	69,712	2,771
January-March, 1945.....	200,247	7,185
January-March, 1944.....	202,143	8,113
<b>Sales</b>		
March, 1945.....	82,932	2,504
February, 1945.....	75,885	2,186
March, 1944.....	72,855	2,705
January-March, 1945.....	234,798	6,796
January-March, 1944.....	207,726	7,849
<b>Stocks on Hand</b>		
March 31, 1945.....	34,452	767
February 28, 1945.....	46,979	1,034
March 31, 1944.....	22,251	750
February 29, 1944.....	18,240	1,092

Manufacturers' Sales Agents for **DOMESTIC**

# Sulphate of Ammonia

Ammonia Liquor

::

Anhydrous Ammonia

**HYDROCARBON PRODUCTS CO., INC.**

500 Fifth Avenue, New York

### Personal Mention

*James T. Phillips* has been chosen president of the Pacific Chemical and Fertilizer Company, Honolulu, Hawaii, succeeding H. A. Walker who became chairman of the board of directors.

*Walter Rowlands*, district supervisor of county agents in Wisconsin, has been appointed director of six branch agricultural experiment stations of Wisconsin.

*Dr. Charles F. Noll*, head of the Department of Agronomy of Pennsylvania State College, retired April 30th after 37 years in service with the institution.

*Richard W. Maycock*, recently treasurer of the Commodity Credit Corporation, has been made vice-president of CCC and director of the Office of Supply.

*Henry A. Huschke* resigned from the Agricultural Chemical Section, OPA, on April 25th, to become managing director of the Agricultural Lime Division of the National Crushed Stone Association with headquarters at present in Washington, D. C.

*Richard Mackay* was elected vice-president and assistant manager of Union Special Machine Company, manufacturers of industrial sewing machines and bag-closing machines, at the March 21st meeting of the company's board of directors. A further change in the personnel of the company was the appointment by the board of G. C. Kopplin, formerly assistant works manager, as works manager, in complete charge of the factory.

### Trade Briefs

**Oilseed Meals.**—Limited amounts of oilseed meals have recently been made available to the fertilizer industry. Soybean and cottonseed meal, including imported cottonseed meal from Brazil—in all too small quantities—were released for fertilizers.

The oilseed meal situation in the feed trade is reported in much better condition, and the need for meal diversions into the feed trade is considered so much reduced that an earnest effort is expected to be made on May 17th at the meeting of the Fertilizer Industry Advisory Committee, to have WFO-5, respecting the use of oil meals for fertilizers, revoked.

**Sulphate of Ammonia.**—Sulphate of Ammonia, in excess of allotments for April and May shipments, has been authorized by the War Production Board for use of fertilizer manufacturers east of the Rocky Mountains. The purpose announced is to permit manufacturers of mixed fertilizers to meet farm demands.

Orders for this added supply of ammonium nitrate can be placed with a qualified supplier. Suppliers submit requests on Form 2947 for approval of WPB.

Any buyer who has not already placed orders for previously assigned tonnage will have to act quickly, else the unordered tonnage will be used to fill new orders.

Buyers who want an additional allotment must accept responsibility, according to WPB, for locating a supplier in position to accept the newly allowed material.

**Nitrate of Soda.**—The War Shipping Administration has announced that a rate of \$16.50 per ton, plus a surcharge of 32 per cent, is to be charged from Chile to Antwerp, Belgium, for nitrate of soda in bags shipped



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## MAGNESIUM LIMESTONE

"It's a Dolomite"

**American Limestone Company**

Knoxville, Tenn.



# NITROGEN for a baby?



THE PROTEIN in a baby's "formula" is but a few steps advanced from the nitrogen you put in your fertilizer. Nitrogen-fed pastures; for instance, are better pastures—grass that is high in protein value will sustain more cows at higher milk-producing levels.

But nitrogen is indispensable in the manufacture of high explosives for the guns of war. These guns have an unbelievable appetite. Right now, they are consuming much of the nitrogen that normally goes into Du Pont Urea-Ammonia Liquors and "Uramon" Fertilizer Compound.

These carriers of Urea Nitrogen offer many benefits to manufacturer and grower

alike. Now is the time to learn how to take full advantage of them—against the day when supplies are again ample.

Our field service men will be glad to consult with you. E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Delaware.

**DU PONT  
UREA-AMMONIA  
LIQUORS**

**URAMON\***

FERTILIZER COMPOUND



BETTER THINGS FOR BETTER LIVING... THROUGH CHEMISTRY

in vessels operated for the account of the WSA.

Under date of April 16th, the Bureau of Mines issued a general license permitting operators of farms to purchase and possess sodium nitrate and ammonium nitrate as fertilizers and sodium chlorate as a weed eradicator, good until December 31, 1945.

May allocations of nitrate of soda by the War Shipping Administration is the largest for the season. The announcement is accompanied with a note of uncertainty that all of the allocation may not be made in May. Nitrate top-dressings of summer crops are largely made in June.

**Superphosphate.**—As reported by The National Fertilizer Association on production of superphosphate by 120 plants, stocks on hand at the end of February were 665,245 tons, including wet base and concentrated, compared to 631,505 tons at the end of February, 1944.

**Sulphur.**—According to the Department of Commerce, Sicilian sulphur production, with an average output of 300,000 metric tons annually for the period of 1937-41, produced only 93,000 tons in 1944 because of the war. Sicilian producers have formed their own organization, the Entente Zolfi Siciliani and are no longer under control of Entente Zolfi Italiana.

**Chemical Trends.**—A report entitled "Chemical Trends and Developments" has again appeared from the Chemical Unit of the Bureau of Foreign and Domestic Commerce of which C. C. Concannon is chief. The report summarizes the situation in inorganic chemicals, organic chemicals, fertilizers, plastics, paints, varnishes and lacquers.

Similar reports, it is announced, will be issued from time to time. The price of the current report is 5 cents a copy, for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C.

**Chemical Industry Steel Allotment.**—By order of the War Production Board, use of steel for maintenance, repair and operating supplies, has been limited during the second

quarter to 80 per cent of the quantity used for the corresponding period of 1944. This action is explained by WPB as necessary by reason of the existing critical supply of steel.

**Union Protests Government Phosphate Plant.**—District Mine Workers of America which operates in a number of fertilizer factories is actively opposing an appropriation of \$3,000,000 to start the construction of a superphosphate plant at Mobile, Ala., as a step in putting the government in competition with private enterprise.

**Phosphate Rock.**—Finely ground Tennessee brown phosphate rock can be sold at 25 cents more per ton where there is a guarantee that 85 per cent will pass through a 300-mesh screen, according to Amendment 2 to RMPR 240, issued by the Office of Price Administration.

### Trading With France

The United States Treasury Department authorized, on April 13th, resumption of private banking arrangements for commercial trade with France. The extent to which trade relations with France will be resumed, it is stated, will soon be made known by the Treasury Department.

The fertilizer industry will, of course, want to know what Alsatian potash producers are proposing with reference to consumption of their product in this country.

### Farm Labor Replacements

Records in Mississippi show a total of 245,056 farm labor replacements with 145,748 different individuals placed on farms in 1944. Cooperation of 6,897 volunteer leaders was received and 691 communities exchanged labor and equipment. Prisoners of war numbering 5,047 were placed at intervals in harvesting essential crops.

The same plans are being carried on this year in an effort to overcome a 43 per cent reduction of farm workers compared with 1940.

<b>Stedman</b>		<b>FERTILIZER PLANT EQUIPMENT</b>			
Dependable for Fifty Years	All-Steel Self-Contained Fertilizer Mixing Units	Batch Mixers— Dry Batching Pan Mixers— Wet Mixing	Swing Hammer and Cage Type Tallings Pulverizers	Vibrating Screens	
				Dust Weigh Hoppers Acid Weigh Scales	
Founded 1834					
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# A Complete Service

**T**HE strategic factory locations of the American Agricultural Chemical Company, as shown on the accompanying map, assure prompt, dependable service for the complete line of products listed below.

We manufacture all grades of Commercial Fertilizers, Superphosphate, Agrinite Tankage, Bone Black, Bone Black Pigments (Cosmic Black), Dicalcium Phosphate, Monocalcium Phosphate, Gelatin, Agricultural Insecticides (including Pyrox, Arsenate of Lead, Calcium Arsenate, etc.), Trisodium and Disodium Phosphate, Phosphorus, Phosphoric Acid, Sulphuric Acid, Ammonium Fluosilicate, Magnesium Fluosilicate, Zinc Fluosilicate, Salt Cake; and we are importers and/or dealers in Nitrate of Soda, Cyanamid, Potash Salts, Sulphate of Ammonia, Raw Bone Meal, Steamed Bone Meal, Sheep and Goat Manure, Fish and Blood. We mine and sell all grades of Florida Pebble Phosphate Rock.



## FACTORIES

Alexandria, Va.	Cleveland, Ohio	No. Weymouth, Mass.
Baltimore, Md.	Detroit, Mich.	Pensacola, Fla.
Buffalo, N. Y.	East St. Louis, Ill.	Pierce, Fla.
Carteret, N. J.	Greensboro, N. C.	Port Hope, Ont., Can.
Cayce, S. C.	Havana, Cuba	Savannah, Ga.
Chambly Canton,	Henderson, N. C.	Seasport, Maine
Quebec, Can.	Montgomery, Ala.	South Amboy, N. J.
Charleston, S. C.	Norfolk, Va.	Spartanburg, S. C.
Cincinnati, Ohio		Wilmington, N. C.

## The AMERICAN AGRICULTURAL CHEMICAL Co.

50 Church Street, New York 7, N. Y.

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Buffalo, N. Y.	East St. Louis, Ill.	Montreal, Quebec, Can.	Savannah, Ga.
Carteret, N. J.	Greensboro, N. C.	New York, N. Y.	Spartanburg, S. C.
Charleston, S. C.	Havana, Cuba	Norfolk, Va.	Wilmington, N. C.
Cincinnati, Ohio	Henderson, N. C.	No. Weymouth, Mass.	
Cleveland, Ohio	Houlton, Me.	Pensacola, Fla.	





## Statutory Liquidated Damages

In a recent decision, the U. S. Supreme Court stated, "No one can doubt but that to allow waiver of statutory wages by agreement would nullify the purposes of the Act (Fair Labor Standards Act). We are of the opinion that the same policy considerations which forbid waiver of basic minimum and overtime wages under the Act, also prohibit waiver of the employee's right to liquidate damage."

Therefore, the Court holds that an employee's release or waiver of his rights to liquidated damages does not preclude him from thereafter recovering such damages and attorney's fees, but holds that interest on underpayments and liquidated damages may not be recovered under the Act.

## Soil Conserving Practices

The Georgia Agricultural Extension Service reporting a survey of 170 Georgia farms made by the Soil Conservation Service, reveals a reduction in the acreage of soil-depleting crops. The corn acreage was reduced 21 per cent and the production increased 21 per cent. Cotton acreage was reduced 26 per cent but the total production was increased 5 per cent. Better land use, improved crop rotations and other soil conservation practices are given credit for the increased yields per acre.

## Agronomic Items

The average yield of cotton in the United States, 1942-44, was 90 per cent above the 1923-32 average. In 1944, on less than half the acreage of the 1923-32 period, 85 per cent as much cotton was produced.

Tobacco growers of the nation have indicated their intention to plant 1,782,000 acres to tobacco, an increase of 4.1 per cent over the 1944 harvested acreage.

Ceiling prices on soybeans for the 1945 crop, announced by the Office of Price Administration, are \$2.10 a bushel for No. 2 yellow and green and \$1.90 a bushel for No. 2 brown and black mixed. The same differentials for grade and quality apply in 1945 as in 1944.

Sixteen counties throughout the United States have been selected to try out all-risk crop insurance on corn this year.

## THE MECHANISM OF CAKING

(Continued from page 10)

**Evaporation of Water:** Perhaps the most common cause of crystallization is evaporation of moisture by exposure to atmospheric humidity below the value corresponding to equilibrium vapor pressure of the solution. This may follow not only from change in atmospheric conditions at a given locality, or from shipping goods from a humid port to a dry warehouse in the interior, but in addition may occur in a pile of goods having appreciable temperature gradients. In the latter case, air currents in a pile, conditioned to a relatively low moisture content by the cool material at the exposed surfaces of the pile, are dry enough when warmed by interior portions to evaporate water from them and thus cause caking. Even when goods are put into storage dry, atmospheric conditions are often severe enough to cause absorption of sufficient moisture at the exposed surface of the pile for solution to seep into the interior where it can cause caking by evaporation as described.

Caking caused by water absorption and subsequent evaporation of the water can be demonstrated as follows in accelerated tests. Small quantities, conveniently a kilogram or so, of products are put into canvas bags and weighted to simulate the effects of pile pressure. Exposure for 24 hours to a controlled humidity above the critical relative humidity for the material in question results in appreciable moisture absorption. Subsequent exposure to a humidity below the critical relative humidity for that product then leads to evaporation of water and caking. It is possible to study the influence of various factors, such as particle size and shape, in accelerated tests of this type. Refinements may be made in order to obtain results of a quantitative nature if desired.

(Continued on page 26)

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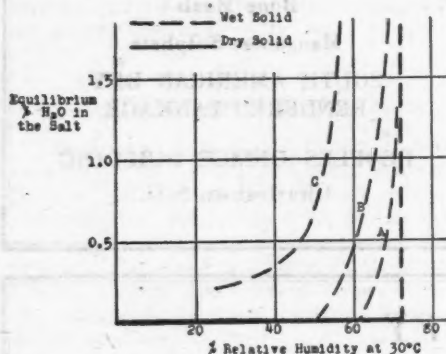
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See Page 4



Strikingly different results can be obtained with similar materials under a given set of conditions. For example, in one experiment of the type described above, three samples of sodium nitrate of similar crystal size and form but differing in impurity content were carried simultaneously through a sequence of humidity exposures. The hygroscopicity properties of the sesamples are shown in Figure 8. Critical relative humidity for pure sodium nitrate as shown by the vertical line at the right of this figure is about 72 per cent. As you see, at all values of relative humidity below 72 per cent, pure sodium nitrate would become or remain dry. At humidities above 72 per cent sodium nitrate goes completely into solution. The three



[Fig. 8—Moisture equilibria for pure sodium nitrate and three sodium nitrate products]

sodium nitrate products used in this test were found to have equilibrium moisture contents at various relative humidities as shown by lines A, B and C. Sample A was a fairly pure material with critical relative humidity on an arbitrary 0.05 per cent moisture basis of about 62 per cent. Sample B was less pure with a corresponding critical relative humidity of about 52 per cent. Sample C was a relatively impure product with critical relative humidity below 30 per cent, with, however, apparently some capacity for hydration.

In the first test all three of these materials,

initially dried, were exposed to a humidity of 70 per cent for 24 hours and then to a humidity of 50 per cent for 24 hours. Product A caked badly. The products B and C, however, were damp but less severely caked. By reference to the figure it will be seen that the exposure humidities bracketed the critical relative humidity of product A but were relatively high with respect to critical relative humidities of products B and C. Accordingly, in this test product A absorbed moisture in the first phase of the cycle and lost moisture in the second phase, resulting in caking. Product B absorbed moisture in the first phase of the cycle, but the moisture absorption in the time allotted in the first phase and the narrow spread between the critical relative humidity for product B and the humidity of exposure in the second phase, resulted in little water evaporation in the second phase and consequently relatively little caking. Sample C was so hygroscopic that it absorbed moisture in both the first and second phases of the cycle and hence was not so severely caked.

In a second test three fresh samples of products A, B and C were used, again initially dry. The humidities of exposures in this case were 60 per cent and 40 per cent. In this test sample A absorbed little or no moisture in the first phase and consequently lost but little in the second phase and therefore caked only slightly. Sample B on the other hand absorbed moisture in the first phase and lost it in the second phase. It caked severely. Sample C absorbed moisture in the first phase but lost relatively little in the second phase because of its low relative humidity. It therefore did not cake severely.

Finally in a sequence of exposures at 50 per cent humidity followed by 30 per cent humidity we have conditions where product C absorbs moisture in the first phase and loses it in the second phase and therefore cakes. On the other hand both products A and B have critical relative humidities too high for absorption of significant moisture at 50 per cent humidity and therefore can not dry out and cake in the second phase of the cycle.

Thus for three products differing only in impurity content, conditions can be found

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for caking any one of them at will without severe caking of the others.

**Temperature:** Crystallization and caking can also be caused by reduction of solubility resulting from temperature changes. In most cases, of course, solubility decreases with decreasing temperature, and the most acute caking attributable to temperature change occurs where damp material is stored hot and cools in the pile.

The critical relative humidity of each salt changes somewhat with temperature, usually decreasing with increasing temperature. The effect is not very large, since in the mathematical formula for this property, namely at a given temperature, the ratio

$$\frac{\text{vapor pressure of saturated salt solution}}{\text{vapor pressure of pure water}} \times 100,$$

the numerator and denominator both change similarly with temperature. The effect is significant, however, particularly for salts which increase considerably in solubility with increasing temperature. In such cases it is sometimes evident that the material is more hygroscopic under summer storage conditions than at lower temperatures.

**Chemical Reaction:** Where chemical reactions occur in stored goods, as is common in the basing practice of the fertilizer industry, the new products are formed by crystallization from a liquid phase, and hence result in caking. Once the stable end products of the reactions are formed, the stabilized mixture is cured, and can no longer cake due to reaction. However, curing reactions are frequently exothermic and cause significant increase of temperature in the goods. Thus even on completion of curing reactions, goods are vulnerable to caking caused by cooling.

**Hydration:** Hygroscopic materials which can take on water of crystallization are usually marketed with less than their full complements of hydration water, to provide residual capacity for water absorption without becoming wet. Such materials in storage frequently exhibit some caking without becoming fully hydrated. This may be taken as evidence that some liquid phase forms either because particle surfaces become fully hydrated and then wet before the interior of the particles is fully hydrated, or because even without full hydration of the surface, a liquid phase is formed by moisture absorption before new crystals of the higher hydrate state can form, due either to a nonhydrating impurity, or to absence of seed crystals of the higher hydrate.

Hydration can be an important element in caking associated with chemical reactions, and moreover in caking associated with decreasing temperature, since it can happen that storage piles cool through temperature levels at which compounds pass from a lower to a higher state of hydration.

**Crystal Transformations:** A few compounds undergo crystal transformations in the range of storage temperatures, without involving hydration. When such changes occur in the presence of liquid phase, caking ensues.

**Pressure:** The pressure that occurs at the base of storage piles, whether in bulk or in bagged goods, promotes caking. In the first place, pressure tends to make more intimate contact and to increase the number of contacts between neighboring particles, thus affording more opportunity for crystallization to cement them together. In the second place, pressure seems to induce recrystallization through the medium of liquid phase when present, perhaps through a higher solubility of highly stressed matter at the small areas of interparticle contact and recrystallization at unstressed surfaces, resulting in relieved stresses because contact areas are made larger.

#### Alleviating Measures

**Exclusion of Moisture:** Because of the importance of liquid phase in caking, exclusion of moisture where practical would go far toward eliminating caking. Granting that some materials can be produced essentially dry by the manufacturer, he can then in general choose any one or combination of three broad measures to protect his product against subsequent acquisition of moisture. He can conceivably coat the particles with an impermeable layer,—if he can find a suitable and effective material. It is known that treatment with P-R-P (petrolatum-rosin-paraffin) coating will at least retard



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somewhat the rate at which hygroscopic salts absorb moisture from a humid atmosphere. Alternatively, he can package his product in containers that prevent or greatly retard acquisition of moisture by the contents. Some materials, for example, can carry the cost of packaging in metal drums. Laminated bags with good resistance to moisture transfer may be the best choice for other materials. Finally, where the manufacturer, or subsequent handlers, can control the place in which the material is stored or shipped, provision of dry conditions, even to the extent of air conditioning, may be justified.

It is recognized that such measures are not always practical or desired. For example, in the normal handling of superphosphate, presence of liquid phase is inevitable and in many ways beneficial, as in permitting ammoniation, and avoiding dusty products. Hence, to the extent that caking is a problem in such cases, other means of reducing its severity are wanted.

**Conditioners:** Several types of materials can serve, in relatively small proportions, to aid in keeping a product in free-flowing form. Absorptive agents like cottonseed meal, cocoa shell meal, etc., tend to take up the moisture in mixed goods and limit its influence on caking. Coating granular or crystalline products with finely divided (the finer the better) nonhygroscopic solids helps prevent contacts between hygroscopic particles, and thus lessens the probability of caking. For example, about 5 per cent of particles smaller than 300 mesh on 10 to 20 mesh granular ammonium nitrate is quite effective. Rough grains require more coating than smooth grains, for equal effectiveness. In some instances products can be packaged in small rigid containers, e.g., table salt. In such cases the contents are not subject to pile pressure in storage, and much smaller proportions of these powdery conditioners can be used effectively. Still another type of conditioner are the oily coatings, such as petrolatum, and blends thereof. They appear to function not only through limiting acquisition of moisture, but also through impeding the migration of moisture on the particle surfaces to regions of interparticle contact.

**Pressure:** Limiting the pressure to which stored goods are subjected is helpful, for example, by limiting the pile height of bulk or bagged material. Where feasible, small rigid containers are effective. For bagged goods, it might in some instances be practical

to arrange shelving or flooring at more frequent intervals to carry the load.

**Physical Form of Product:** Large particle products cake less under a given set of conditions than do the same materials in the form of small particles. Granular particles with internal porosity tend to cake less than similar materials in compact form, and are satisfactory when mechanically strong.

**Curing:** When the economics of production requires the mixing and then storage of solid materials which undergo chemical reaction, the practice of curing and subsequent disintegration of the reacted mass is called for, as is well known to the fertilizer industry.

**Timing:** Of course the longer goods are left in conditions conducive to caking, the worse they will cake. It is possible for an adroit manufacturer to improve the conditions of his goods as used by the consumer, by seeing that the time between shipment in good condition from his last point of control, and use by the consumer, is as short as possible, and that in the interim, conditions are as favorable as possible.

### Dehydrated Sweet Potatoes Army Food Favorite

Dehydrated sweet potatoes are a popular food with American soldiers and would be served more frequently if present stocks permitted food preferences to be followed, according to an Army spokesman.

Approximately 2½ million bushels of sweet potatoes out of the 1945 crop are to be used for overseas shipments. Six pounds of fresh potatoes are required to make one pound of the dehydrated product.

The 1945 goal for sweet potato plantings is 841,000 acres, 8 per cent greater than the acreage planted last year, from which 71 million bushels are expected.

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DuPont de Nemours & Co., E. I., Wilmington, Del.

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"The American Fertilizer"

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For an Alphabetical List of all the  
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Schmalts, Jos. H., Chicago, Ill.  
Wellmann, William E., Baltimore, Md.

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International Minerals & Chemical Corp., Chicago, Ill.  
United States Potash Co., New York City.

### PYRITES—Brokers

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Wellmann, William E., Baltimore, Md.

### REPAIR PARTS AND CASTINGS

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Utility Works, The, East Point, Ga.

### ROUGH AMMONIATES

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Schmalts, Jos. H., Chicago, Ill.  
Wellmann, William E., Baltimore, Md.

### SCALES—Including Automatic Bagging

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Huber & Company, New York City.  
Hydrocarbon Products Co., New York City.  
McIver & Son, Alex. M., Charleston, S. C.  
Nitrogen Products, Inc., New York City  
Schmaltz, Jos. H., Chicago, Ill.  
Wellmann, William E., Baltimore, Md.

### SULPHUR

Ashcraft-Wilkinson Co., Atlanta, Ga.  
Texas Gulf Sulphur Co., New York City.

### SULPHURIC ACID

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Armour Fertilizer Works, Atlanta, Ga.  
Ashcraft-Wilkinson Co., Atlanta, Ga.  
Bradley & Baker, New York City.  
Huber & Company, New York City.  
International Minerals & Chemical Corporation, Chicago, Ill.  
McIver & Son, Alex. M., Charleston, S. C.  
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Wellmann, William E., Baltimore, Md.

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Huber & Company, New York City.  
International Minerals & Chemical Corporation, Chicago, Ill.  
McIver & Son, Alex. M., Charleston, S. C.  
Schmaltz, Jos. H., Chicago, Ill.  
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.  
Wellmann, William E., Baltimore, Md.

### SUPERPHOSPHATE—Concentrated

Armour Fertilizer Works, Atlanta, Ga.  
International Minerals & Chemical Corporation, Chicago, Ill.  
Phosphate Mining Co., The, New York City.  
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

### TANKAGE

American Agricultural Chemical Co., New York City.  
Armour Fertilizer Works, Atlanta, Ga.  
Ashcraft-Wilkinson Co., Atlanta, Ga.  
Bradley & Baker, New York City.  
International Minerals & Chemical Corporation, Chicago, Ill.  
McIver & Son, Alex. M., Charleston, S. C.  
Schmaltz, Jos. H., Chicago, Ill.  
Wellmann, William E., Baltimore, Md.

### UREA

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### VALVES

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Utility Works, The, East Point, Ga.

### ZINC SULPHATE

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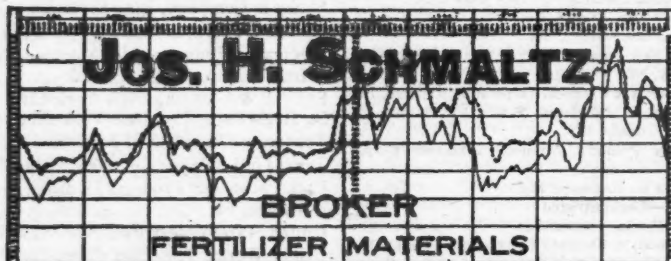
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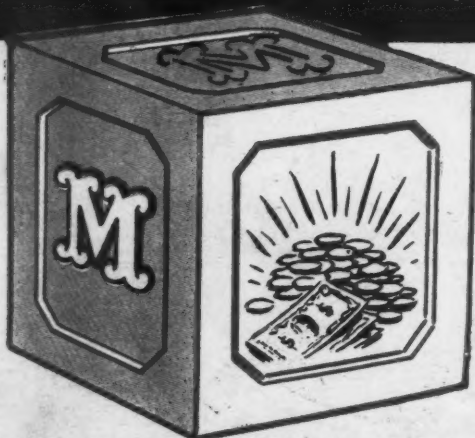
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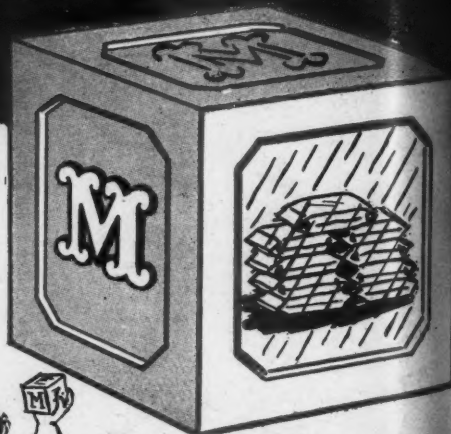
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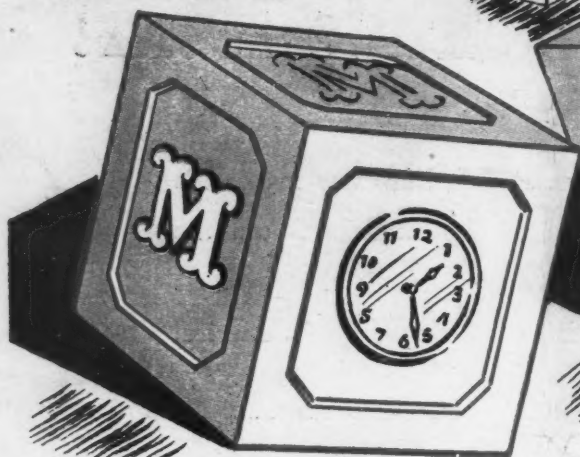
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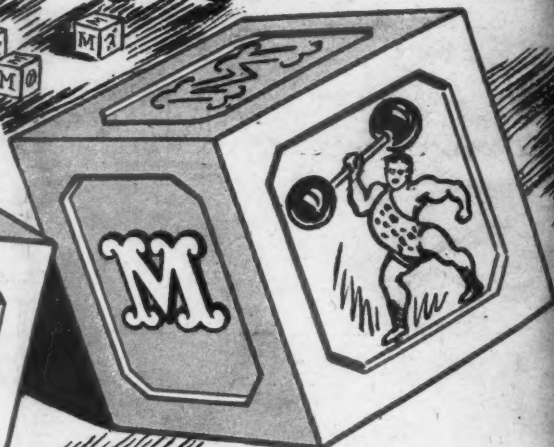
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